Understanding Mobile Coverage & Reception

- ATSC Mobile DTV reception is based on different planning factors than terrestrial DTV reception
  - Receive antenna height   45” vs. 30 ft.
  - Receive antenna gain   -20db to -3db vs. 0db
  - System SNR   3.5 – 7.0db vs. 15db

- Field testing has shown that the “radio horizon” is the limit to reliable mobile/handheld coverage
  - Typically line of sight from TX antenna to receiver
  - Limitations typically are terrain and buildings
  - Flat terrain + tall towers + H&V pol + max power = 35 -45 mile coverage

Targeted MDTV Coverage

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- Broadcasters have indicated that they are most concerned with delivering coverage to:
  - Urban canyon areas
  - Interiors of large buildings
  - Urban areas that are terrain shielded

"Signal Saturation" vs "Coverage Contours" will become the principal criteria for successful performance

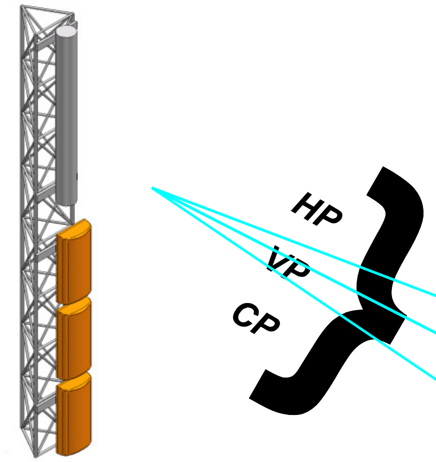
Achieving Signal Saturation

- Circular polarization
  – Discussion to follow

- Maximized Power from main TX site
  – Achieved by low antenna gain and high transmitter power output

- Gap fillers and Repeaters
  – Synchronized or OTA

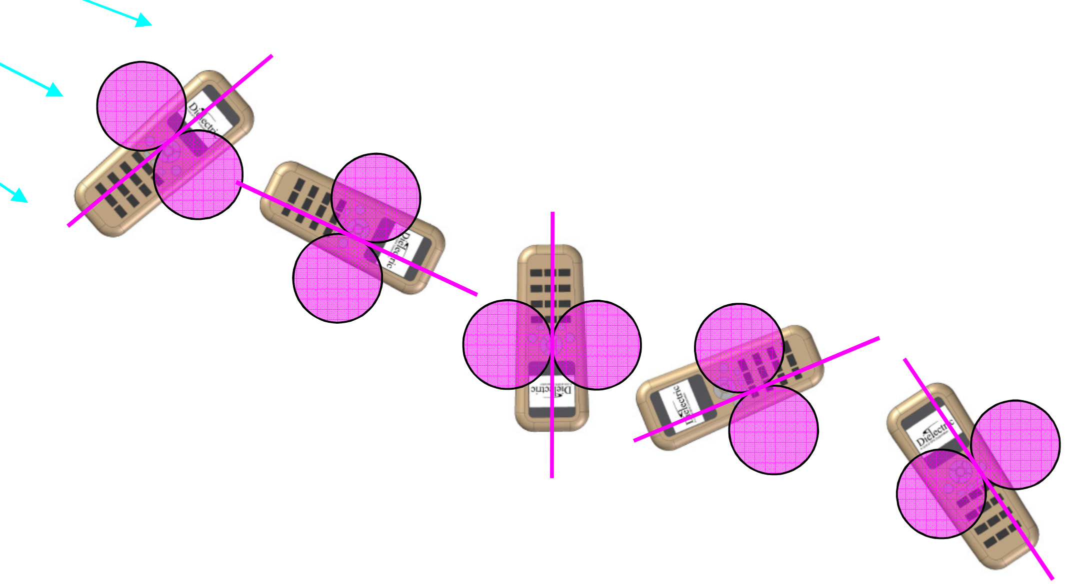
Why Circular Polarization is Important

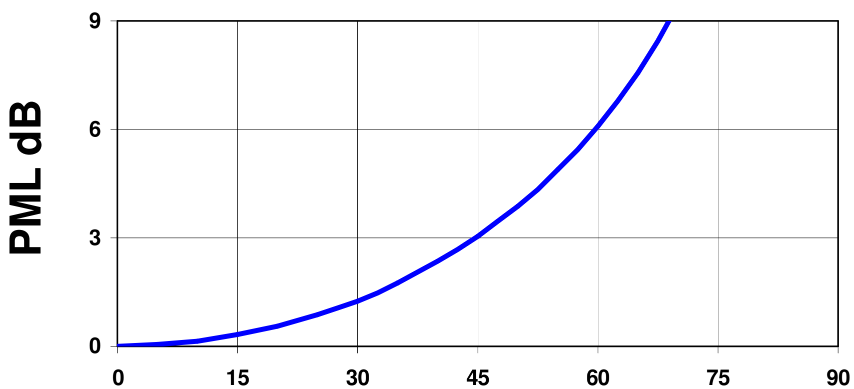


Polarization Mismatch Loss

(Depolarization)

Caused by misalignment between the transmit and receive antenna

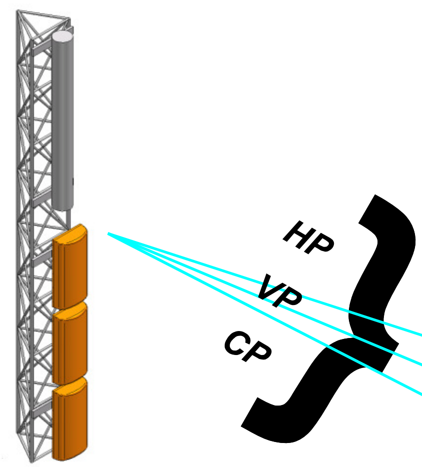


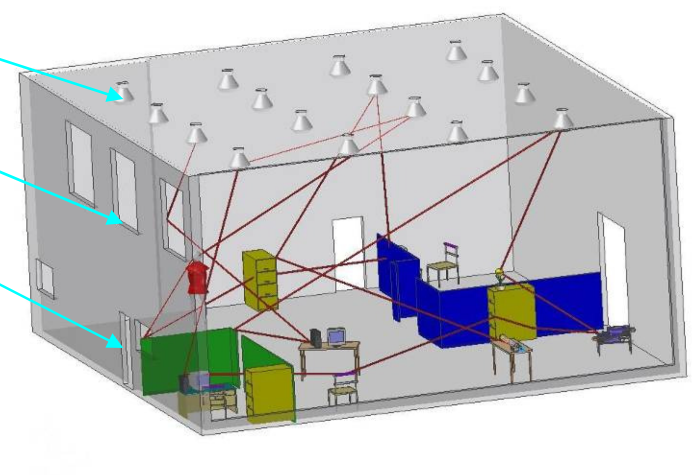


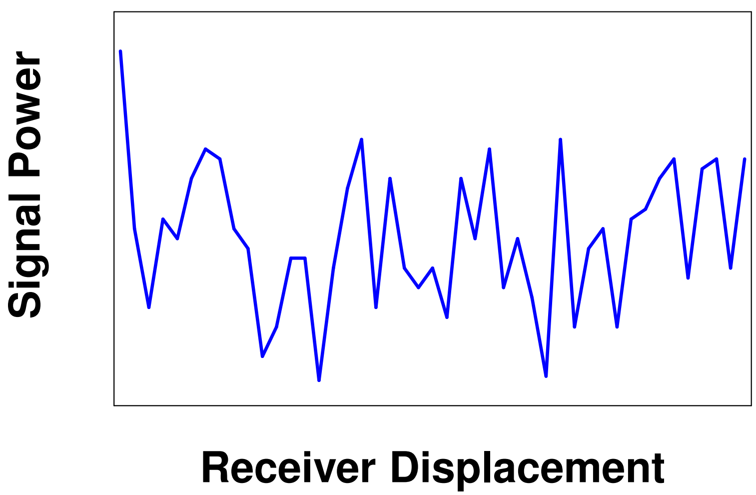
Why Circular Polarization is Important

Small scale fading occurs when multiple signals arrive at the receiver from nearby reflecting objects

The vector addition of all multi-path components create variations in the received signal strength





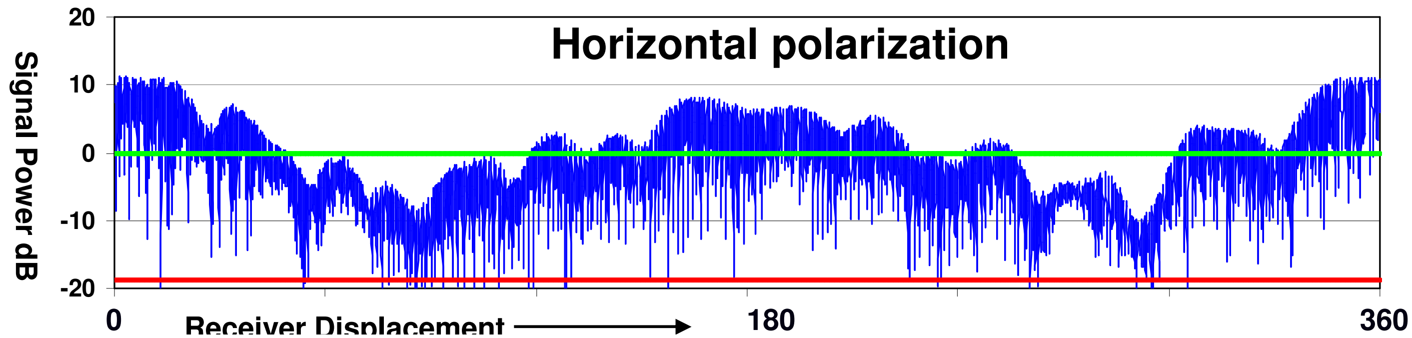


CP results in improved signal availability

Mean

$\sigma = -18.7dB$

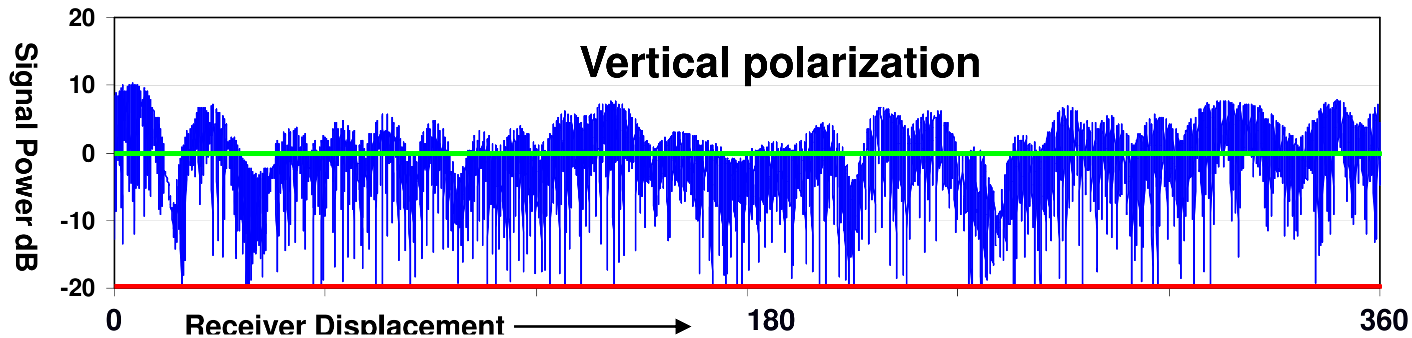
98 % Service



Mean

$\sigma = -19.7dB$

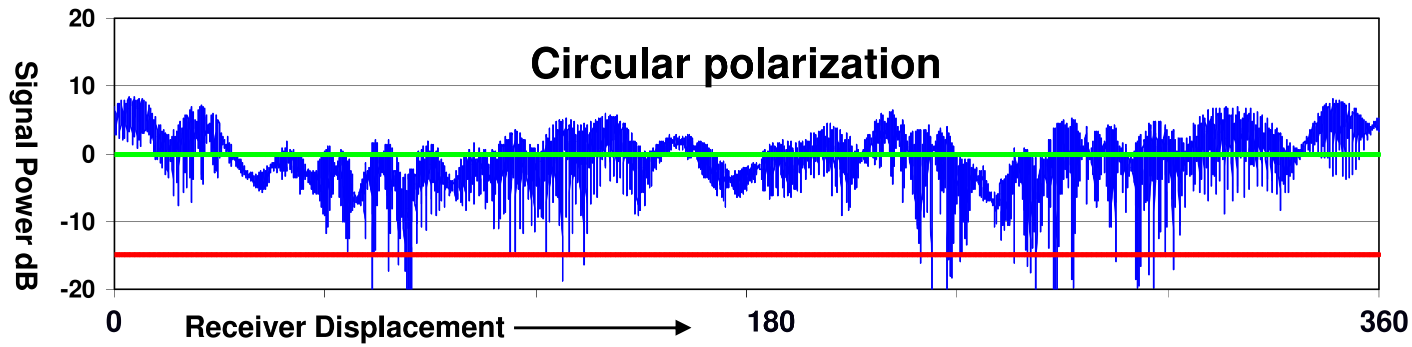
98 % Service



Mean

$\sigma = -14.8dB$

98 % Service



700 MHz

Test Results Summary - UHF

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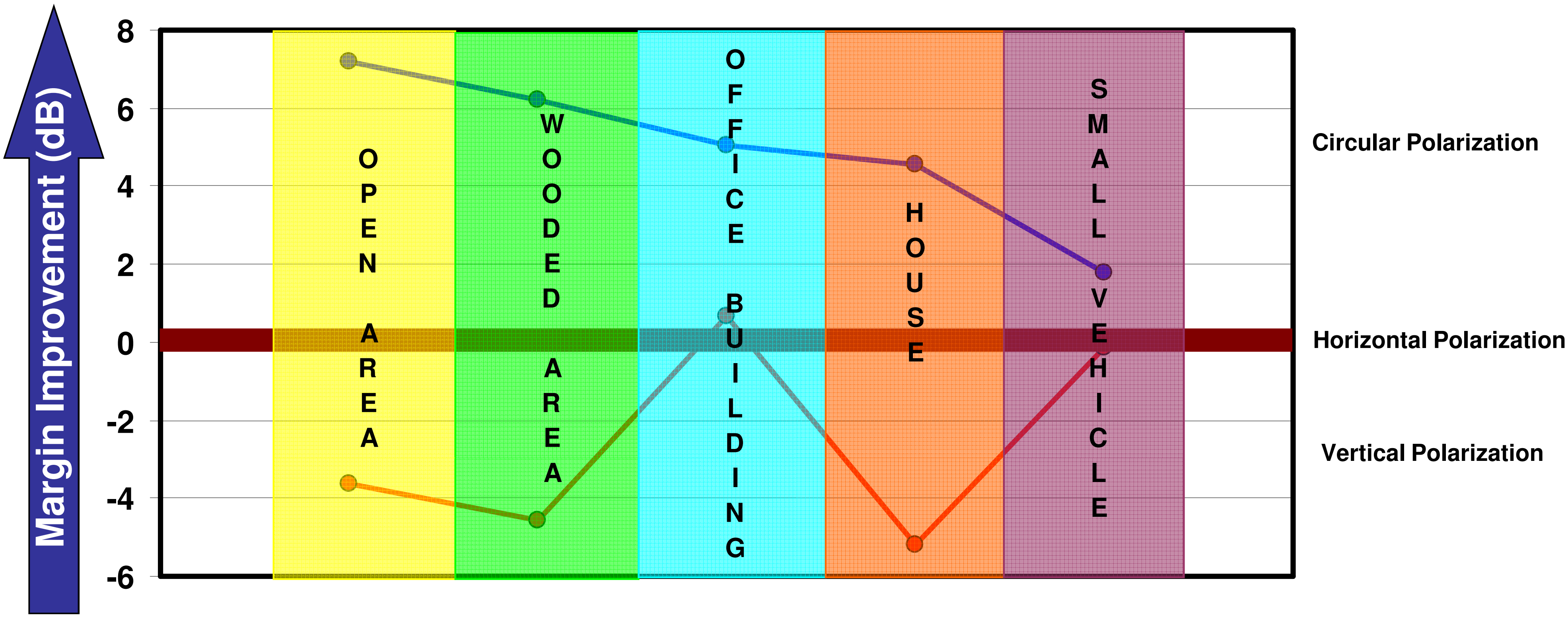
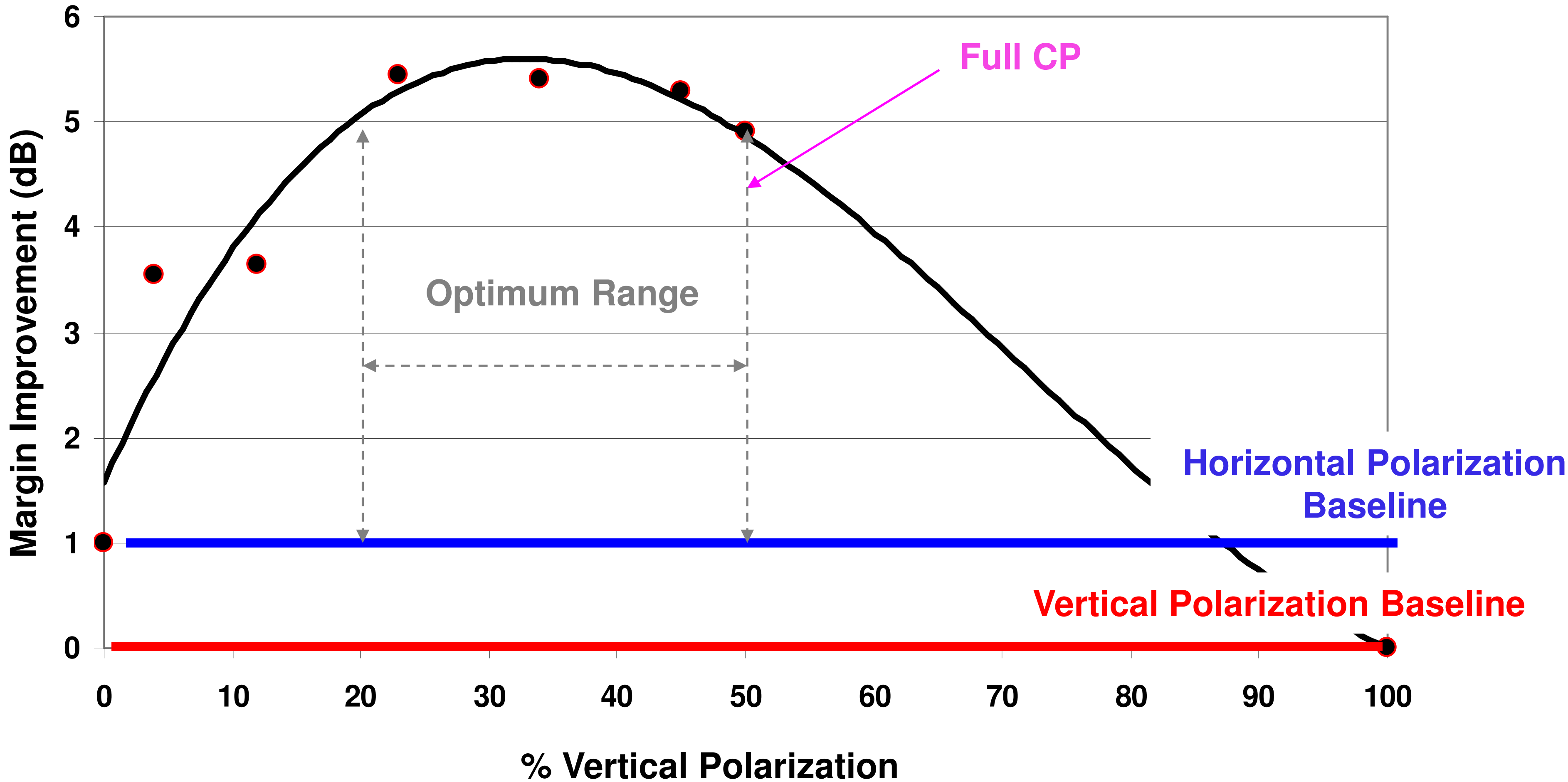


- On average, circular polarization offers 5 dB margin improvement over horizontal polarization
- On average, circular polarization offers 7.5 dB margin improvement over vertical polarization

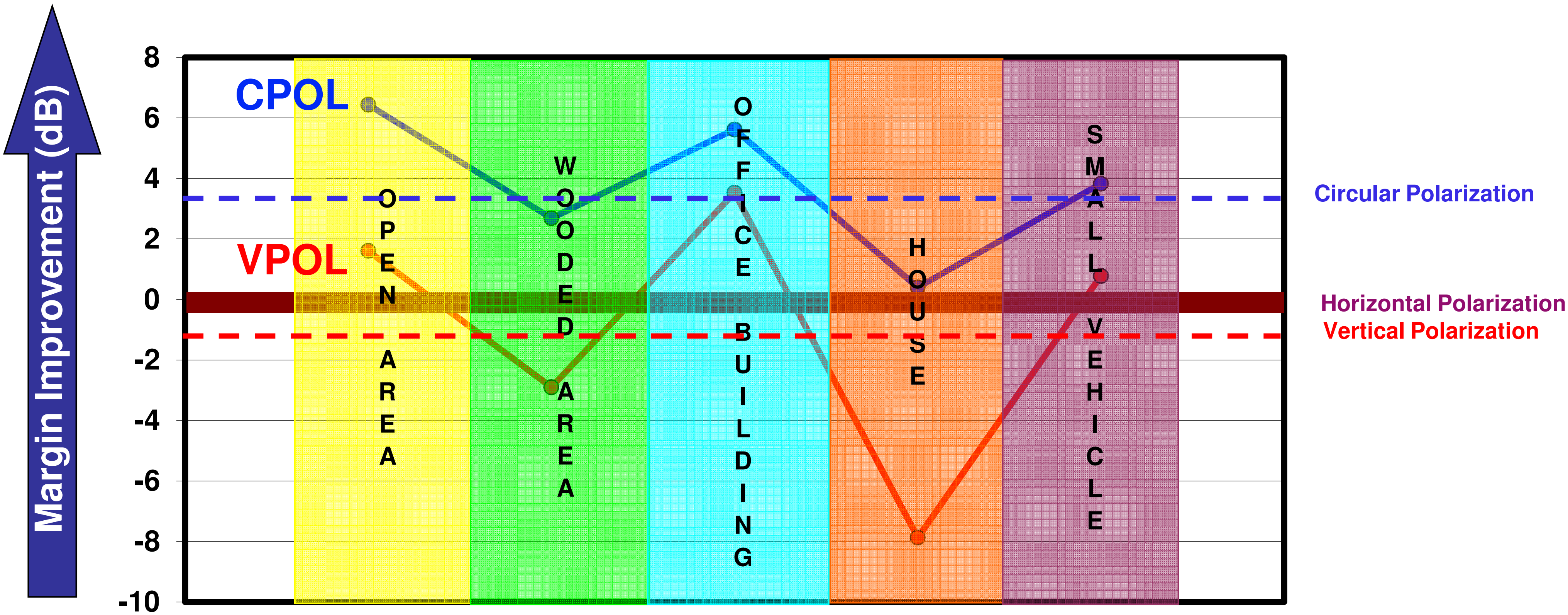
Test Results Summary - UHF

Greatest Margin Occurs at 33% Vertical Component



More than 4 dB of margin improvement with 20% < Vpol < 50%

Results Summary - VHF



- On average, circular polarization offers 3.5 dB margin improvement over horizontal polarization
- On average, circular polarization offers 4.5 dB margin improvement over vertical polarization

Frequency 210 MHz

VHF Observations

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- On a small handheld receiver, VHF provides:
  - Less polarization discrimination
  - Greater orientational immunity
  - “Omni Polarized”
- On average circular polarization provided 3.5 dB of margin improvement over horizontal polarization

Great news for VHF….right?

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Average Received Signal Strength UHF vs. VHF

Link Budget Differences

	VHF	UHF
Antenna Gain	-3.1 dB	0.0 dB
Tx Power	-4.0 dB	0.0 dB
Tx Cable	3.6 dB	0.0 dB
Rx Cable	0.5 dB	0.0 dB
Rx Ant. VSWR	-9.5 dB	0.0 dB
Free space loss	9.8 dB	0.0 dB
Adjustment Factor	-2.7 dB	0.0 dB

Average Field Strength

	UHF	VHF	Adjusted VHF
Open	-31.8 dBm	-56.0 dBm	-53.3 dBm
Woods	-38.2 dBm	-55.7 dBm	-53.0 dBm
Office	-45.2 dBm	-72.0 dBm	-69.3 dBm
House	-57.9 dBm	-75.2 dBm	-72.5 dBm
Vehicle	-40.6 dBm	-64.9 dBm	-62.2 dBm
Avg	-42.7 dBm	-64.8 dBm	-62.1 dBm

VHF had 19.4 dB less average signal strength than UHF

Small Receive Antennas

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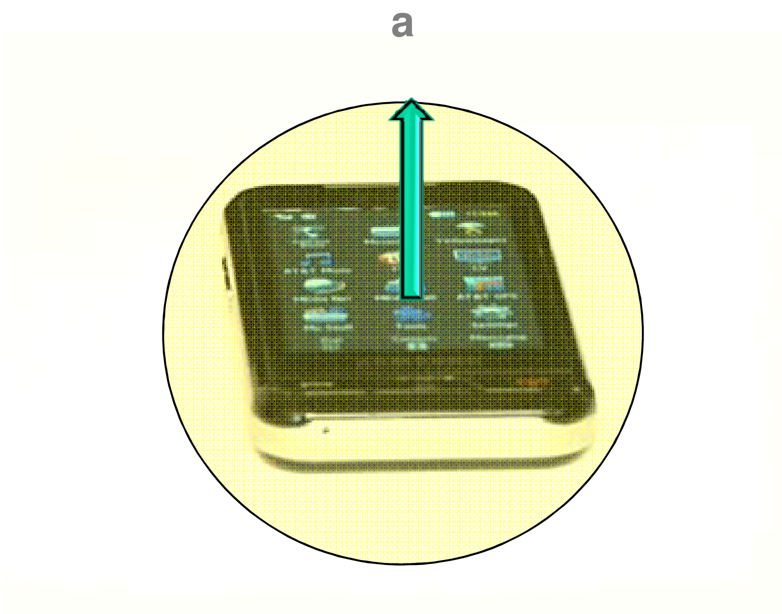
Harold Wheeler defined the fundamental limitations of electrically small antennas based on their size

Electrically small antenna – max dimension $\leq \lambda/2\pi$

~3”   UHF

~8.5” VHF



Max power factor: $P_{max} = (ka)^3$

a = antenna volume radius

$k = 2\pi/\lambda$

Wheeler Limit

Solve for the max power ratio difference between 210 MHz and 700 MHz

$$\frac{\rho_v}{\rho_u} = 10\log\left[\frac{\left(\frac{2\pi}{\lambda_v}a\right)^3}{\left(\frac{2\pi}{\lambda_u}a\right)^3}\right] = 10\log\left(\left(\frac{\lambda_u}{\lambda_v}\right)^3\right) \approx -15dB$$

Wheeler Limit dictates the best VHF/UHF receive ratio of an electrically small antenna will be -15 dB